THE ASTROPHYSICAL JOURNAL, 189:L135–L136, 1974 May 1

A NEW SOURCE OF INTENSE MOLECULAR EMISSION IN THE RHO OPHIUCHI COMPLEX

P. J. ENCRENAZ*†
Goddard Institute for Space Studies, New York City
Received 1974 January 31

ABSTRACT

A new source of intense molecular line emission has been found in a dark cloud in the ρ Ophiuchi complex. The densities implied by the observations are higher than 10^5 cm^{-3}.

Subject headings: molecules, interstellar — spectra, molecular

I. INTRODUCTION

During an extensive survey of CO emission from dark clouds, we have found an interesting new source of millimeter molecular line emission in the ρ Ophiuchi complex. Double-peaked $^{12}C^{16}O$ profiles have been observed while corresponding $^{13}C^{16}O$ and $^{12}C^{18}O$ profiles are only single-peaked. We also detected the $J = 2 \rightarrow 1$ and $J = 3 \rightarrow 2$ CS transitions, and the 1_{10}–2_{11} and 1_{11}–2_{12} H_2CO 2-mm lines at the position of the strongest $^{13}C^{16}O$ profile. All lines appear in emission, and the present observations imply that at least one dust cloud has densities higher than 10^5 cm^{-3} in its core. A complete map of the cloud will be published elsewhere (Encrenaz 1974).

II. OBSERVATIONS

Observations were done at the Millimeter Wave Observatory at Mount Locke.[1] A 40-channel backend gave us a resolution of 0.79, 0.65, and 0.52 km s^{-1} at 97 GHz (CS $2 \rightarrow 1$), 115 GHz (CO $1 \rightarrow 0$), and 147 GHz (CS $3 \rightarrow 2$), respectively. The noise figure was 1200°–1500° K depending on the frequency (double sideband). The peak of the observed $^{13}C^{16}O$ is at the position

$$\alpha_0(1950) = 16^h23^m10^s \pm 4^s ;$$

$$\delta_0(1950) = -24°18'20'' \pm 1'' .$$

Plots of the observed line profiles in this direction are given in figure 1. A summary of the observations is given in table 1.

III. DISCUSSION

While the $^{12}C^{16}O$ line is observed over a few square degrees, the source of strongest millimeter emission is much smaller: its dimensions are at least $3' \times 6'$, and possibly $6' \times 8'$ in the CS $3 \rightarrow 2$ line. The detection of the CS $J = 3 \rightarrow 2$ and 2-mm H_2CO lines implies densities in excess of 10^5 cm^{-3} in the center of the cloud if collisional excitation of molecules is assumed (Penzias *et al.* 1971; Thaddeus *et al.* 1971). As can be seen from figure 1, the second component of $^{12}C^{16}O$ at +5.2 km s^{-1} has no counterpart in $^{13}C^{16}O$ nor in any other molecule. A lower limit of the $^{12}C/^{13}C$ ratio of 30 can already be set in the wings of the +5.2 km s^{-1} component of the profile. A more detailed analysis of the isotopic ratios in the cloud is under way. Near this position, Simon *et al.* (1974) have observed a source of 50,000 f.u. at 350 μ,[2] and it is interesting to note that Grasdalen, Strom, and Strom (1973) have detected many infrared stars nearby. A detection by Brown and Knapp (1973) of a C^+ recombination line at 21 cm (a unique case

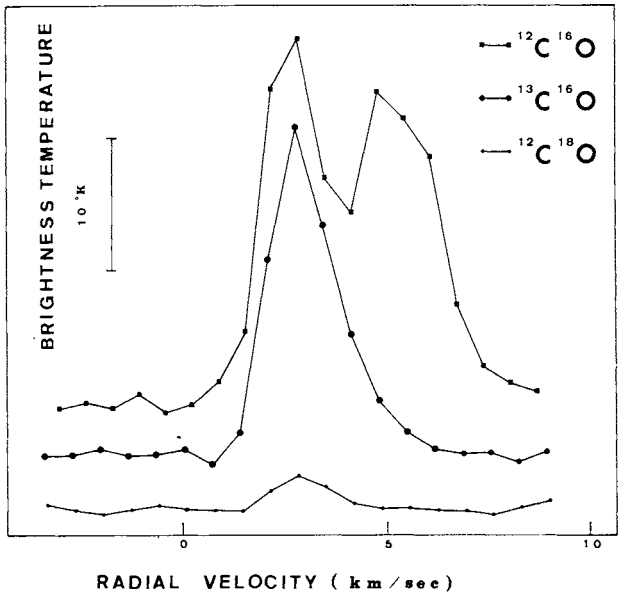

FIG. 1.—$J = 1 \rightarrow 0$ spectra of the three most abundant isotopic species of CO in the direction of the new molecular source. The brightness temperature in both $^{12}C^{16}O$ and $^{13}C^{16}O$ is approximately the same at +2.8 km s^{-1}, a unique case among CO sources so far discovered.

* On leave from Meudon Observatory, Paris.

† Resident Research Associate, National Research Council, supported by the National Aeronautics and Space Administration.

[1] The Millimeter Wave Observatory at Mount Locke is operated by the Electrical Engineering Research Laboratory, the University of Texas at Austin, with support from the NASA, the NSF, and the McDonald Observatory.

[2] 1 flux unit = 10^{-26} W m^{-2} Hz^{-1}.

TABLE 1

Molecule	Molecular Transition	T_b(peak) (°K)	ΔV(km s^{-1})	V_{LSR}(km s^{-1})
$^{12}C^{16}O$	$J=1\rightarrow0$	27.5 (and 23.7) ±0.2	2.0 (and 2.0) ±0.2	2.8 (and 5.2) ±0.2
$^{13}C^{16}O$	$J=1\rightarrow0$	25.0 ±0.2	2.0±0.2	2.8±0.3
$^{12}C^{18}O$	$J=1\rightarrow0$	2.3 ±0.1	1.3±0.3	2.8±0.3
$^{12}C^{17}O$	$J=1\rightarrow0$	0.25±0.08	hyperfine structure	2.8±0.3
H_2CO.....	$2_{12}\rightarrow1_{11}$	2.1 ±0.3	1.5±0.2	2.7±0.2
H_2CO.....	$2_{11}\rightarrow1_{10}$	1.3 ±0.3	1.5±0.2	2.6±0.2
CS	$J=2\rightarrow1$	3.0 ±0.6	1.7±0.4	3.0±0.5
CS	$J=3\rightarrow2$	2.1 ±0.3	1.4±0.2	3.2±0.5
SO*	$3_2\rightarrow2_1$	1.4 ±?	1.9±0.8	3.1±0.4
U87.3†	...	0.7 ±?	...	3.0±0.3

NOTE.—T_b (peak) is the peak brightness temperature corrected for atmospheric attenuation. The error quoted is the rms noise in the baseline of each profile. Even so, each brightness temperature may be in error by as much as 20% due to the calibration procedure. ΔV is the width of the profile at half-intensity.

* Gottlieb and Ball 1973.

† Private communication from K. Tucker, M. Kutner, and P. Thaddeus.

among dark clouds) and the intensities of the molecular lines observed indicate that we are dealing with a remarkably interesting region, at least as interesting as the Orion molecular clouds. A search for other recombination lines, radio continuum emission and other molecules would certainly give new insights into this extraordinary source.

All these observations would not have been possible without the help and advice of R. L. Dickmann, M. Kutner, A. Penzias, P. Thaddeus, and K. Tucker. The Schottky barrier diodes used in this work have been made by G. T. Wrixon and M. Schneider and mounted by R. Linke, all of Bell Telephone Laboratories. R. Lucas helped to reduce the data.

REFERENCES

Brown, R. L., and Knapp, G. R. 1973, preprint.
Encrenaz, P. J. 1974, in preparation.
Gottlieb, C. A., and Ball, J. A. 1973, *Ap. J.* (*Letters*), **184**, L59.
Grasdalen, G. L., Strom, K. M., and Strom, S. E. 1973, *Ap. J.* (*Letters*), **184**, L53.
Penzias, A. A., Solomon, P. M., Wilson, R. W., and Jefferts, K. B. 1971, *Ap. J.* (*Letters*), **168**, L53.
Simon, M., Righini, G., Joyce, R. R., and Gezari, D. Y. 1973, preprint.
Thaddeus, P., Wilson, R. W., Kutner, M., Penzias, A. A., and Jefferts, K. B. 1971, *Ap. J.* (*Letters*), **168**, L59.